High Performance Epoxy System for Lightweighing in Automotive Industry

2019. 05. 09

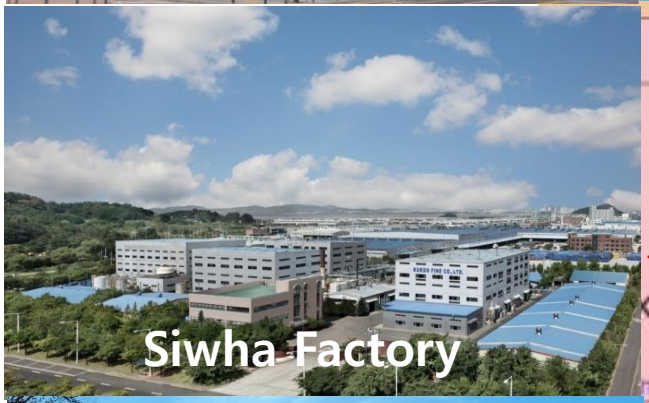
Kukdo Chemical
Chongsoo Park, Ph. D

KUKDO Chemical Outlines

- Establishment : Feb. 22. **1972**
- Paid Capital : USD 27,000,000
- Stock Enlisted : Aug. 5. 1989
- Range of Products : Epoxy Resin & Hardener, Polyurea, Polyol
- Turnover : 2018 USD **1.18** BIL
- Employees : 650 (990 INCLUDING CHINA)
- Certificates :
  - ISO **9001** (Quality Management System) : Mar. 1994
  - ISO **14001** (Environmental Management System) : Dec. 1995
  - KOSHA/OHSAS **18001** (Safety Management System) : Aug. 2010/No. 2011
  - **Germanischer Lloyd Approval** (Epoxy systems for wind blades) : May 2009
  - A.E.O (Authorized Economic Operator) : Sep. 2011
  - AS 9100 under preparation

Visit www.kukdo.com for more detail information

Location of Office & Factories



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Manufacturing & Logistic Networks

- NA Region W/H : Morden (Canada) / Houston TX, Chicago IL, Atlanta GA, Newark NJ (USA)
- EU Region W/H : Rotterdam (Netherlands)
- MER Region W/H: Istanbul, Izmir (Turkey)
- WA Region W/H : Mumbai (India; Visibility Study)
- Manufacturing Site: Iksan, Sihwa, Pusan (Korea), Konshan, Ningbo(under construction) (China), Guzalat(under construction(India)

Outline of KUKDO Epoxy Products

GENERAL EPOXY	Bisphenol A type Epoxy Resin	EPOKUKDO YD-series
	Bisphenol F type Epoxy Resin	EPOKUKDO YDF-series
	Hydrogenated BPA Epoxy Resin	EPOKUKDO ST-series
	Epoxy Resin for P.C.M	EPOKUKDO YD, KU-series
EPOXY FOR ELECTRONIC, ELCETRIC	Brominated Epoxy Resin	EPOKUKDO YDB-series
	Non-Halogen Epoxy Resin	EPOKUKDO KDP-series
	Novolac Epoxy Resin	EPOKUKDO YDPN, UDCN, KBPN, DCPD-series
	Electric Molding Epoxy Resin	EPOKUKDO KC, YD-series
HIGH-FUNCTIONAL EPOXY	UV-Curing type Epoxy Resin	EPOKUKDO YDU-series
	Low Temperature Curing Epoxy Resin	EPOKUKDO KDN-series
	Phenoxy Resin	EPOKUKDO YP-series
	Multi-Functional Epoxy Resin	EPOKUKDO YH, KDT-series
ENVIRON-MENTAL FRIENDLY EPOXY	Flexible Resin	EPOKUKDO YD, KR-series
	High Purity-Low Chlorine Epoxy Resin	EPOKUKDO YDs-series
REACTIVE DILUENT	Waterborne Epoxy Resin	EPOKUKDO KEM-series
	BADGE Free Epoxy Resin	EPOKUKDO KD-series
	Epoxy Diluent	EPOKUKDO ME-series

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Outline of KUKDO FineChem Products line

1. Epoxy Functional Reactive Diluents and Resins

- Monofunctional Aliphatic Glycidyl Ethers
- Monofunctional Aromatic Glycidyl Ethers
- Multifunctional Glycidyl Ethers
- Multifunctional Glycidyl Esters
- Multifunctional Glycidyl Amines
- Low –Cl Mono, Multi type Glycidyl Ethers
- High purity Mono , Multi type Glycidyl Ethers

2. Tin Catalyst

- DBTDL, Potassium Octoate, Tin Octoate, Bismuth Tris 2 ethyl hexoate

3. Anhydride Hardener

- MTHPA, MHHPA, HHPA, MNA, (DDSA)

KUKDO's Epoxy Application

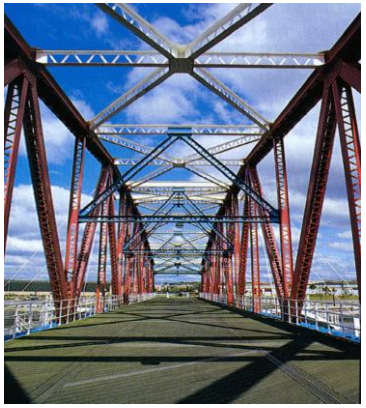
Paints & Coatings

Mid-coats and decks

containers

Rebar coating

Offshore



Bridges

Functional Powder Coatings

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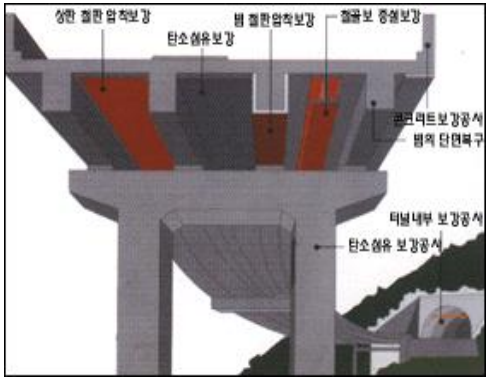
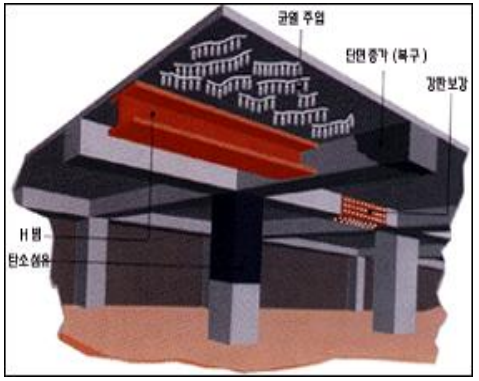
KUKDO's Epoxy Application

Construction & Civil Works

Man made river project in Libya

Epoxy Floor

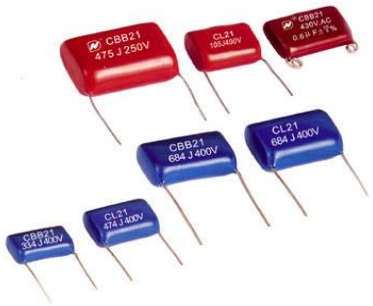




Epoxy Reinforcement for repairing

KUKDO's Epoxy Application

Electric & Electronic Application



Epoxy Insulation

PDP & LCD

Computer

Digital Convergence Tech

Mobile phone

Epoxy Transformer

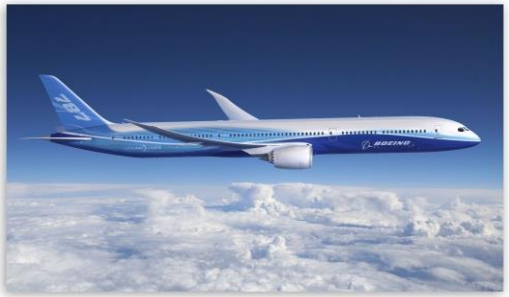
LED

KUKDO's Epoxy Application

Composite Application

Epoxy Wind Blade

F/W Pipe



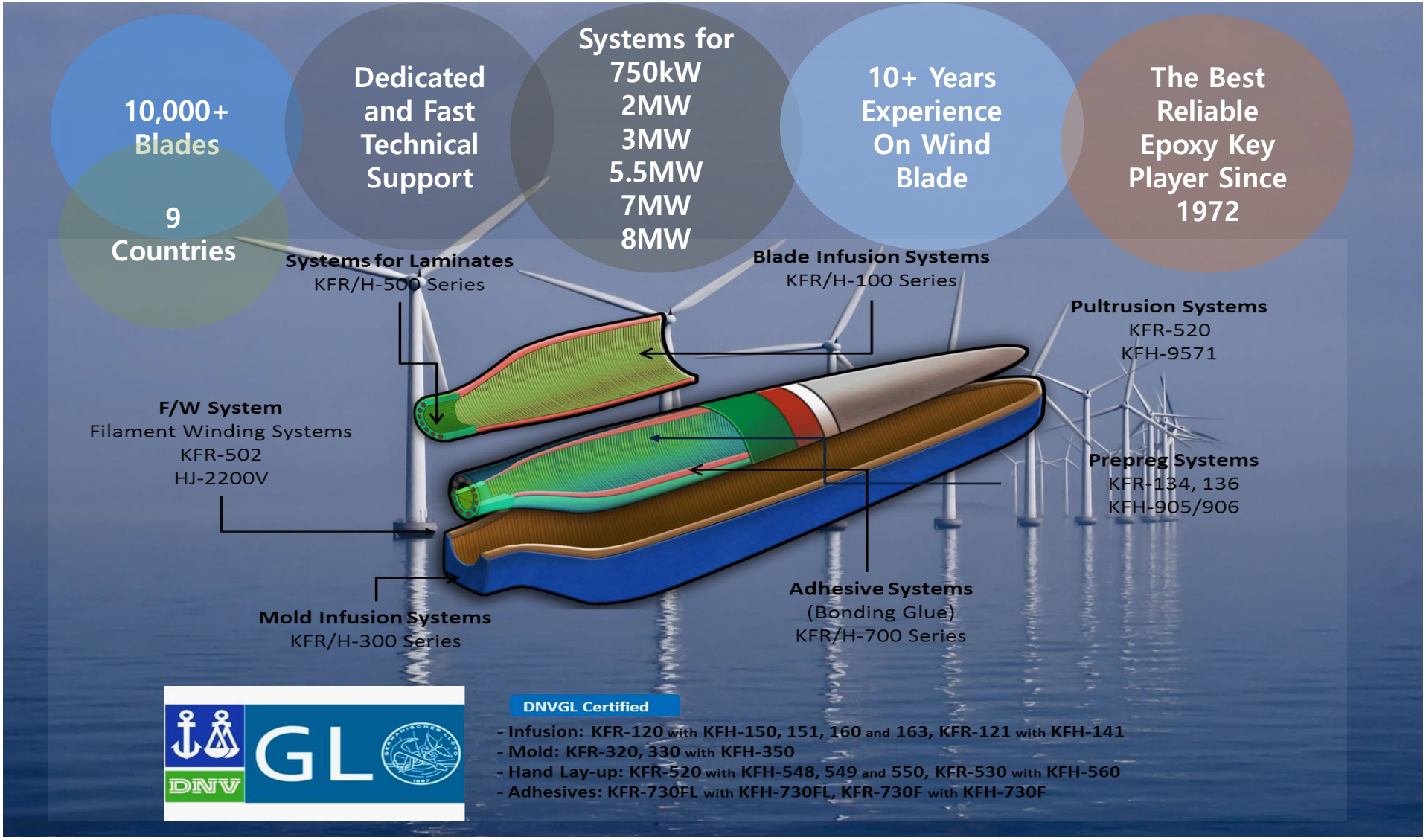
Airplane

Automobile

Train

Sports

KUKDO System Epoxy for Wind Blades



KUKDO System Epoxy for Automotive

KUKDO Epoxy Resin for Aerospace

Glycidyl Amine Epoxy Resins : KDS-8805, 8808, PA-806L Series

Special Novolac Resins : YDPN, YDCN, KBPN, KDMN Series

Isocyanated Modified Epoxy Resin : KFR-31085, 31185

Toughened Epoxy Resin : KFR-5521, 5522, KR Series

KUKDO System Epoxy for General Industry

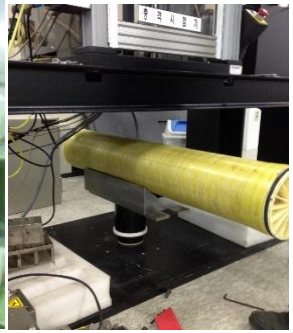
Filament Winding : KFR-120, 520, KDS-8128 Series

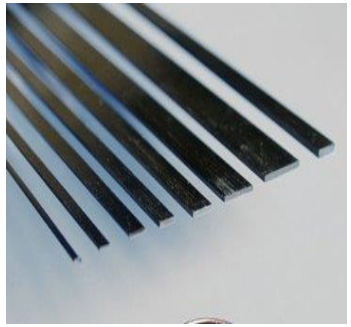
Pultrusion : KFR-120, 520, KFR-6016 Series

Hand Lay-up : KFR-502, 503, 520, 530 Series

Infusion : KFR-120 Series

Prepreg : KFR-5510 Series





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Epoxy Resin as Matrix for Composite

Advantages of Epoxy Resin

Excellent adhesion, Chemical(Corrosion) and Heat resistance, Mechanical properties, Good dimension stability and low shrinkage.

Reliable Total Cost

Competitive in price of resin to compare the other thermosetting resins and reliable total cost including process cost and machinery equipment.

Composition of epoxy composite

Epoxy resin, Hardener, Accelerator, reinforcement fiber or fabrics, coupling agents, Diluents, releasing agent, organic or inorganic pigment, fillers, various additives

Considerable factor of Epoxy composite

Chemistry of epoxy resin & hardener, viscosity of resin & hardener and reactivity (Pot life, gel time), cure condition), Cured Tg and cured mechanical properties

Epoxy Resin as Matrix for Composite

Reinforcements

Easily can be reinforced with various fiber, yarn, fabric, chips.
(Glass fiber, Carbon fiber, synthetic fiber, natural fiber, Nylon, Aramid and etcs)
CNT, graphene, rubber, engineering plastics and flame retardants.

Compliable Processes

Infusion, Hand Lay-up/Spray-up, SMC/BMC, Autoclave,
Resin Transfer Molding (RTM), Filament Winding, Pultrusion,
High Pressure Resin Transfer Molding (HP-RTM), Wet Compression Molding (WCM)
and Prepreg Compression Molding(PCM)

Applicable industries

Various industries such as construction, Transportation(Automotive, train, Aircraft),
Sports, electronics, Ship building(boat, yacht, ships), renewable energies and etc.

Applications of Carbon Fiber as Lightweight Material

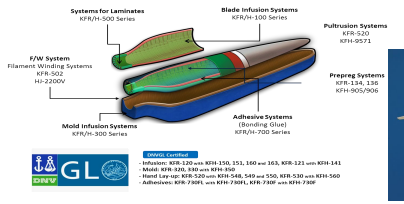
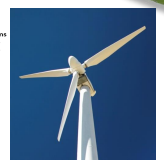








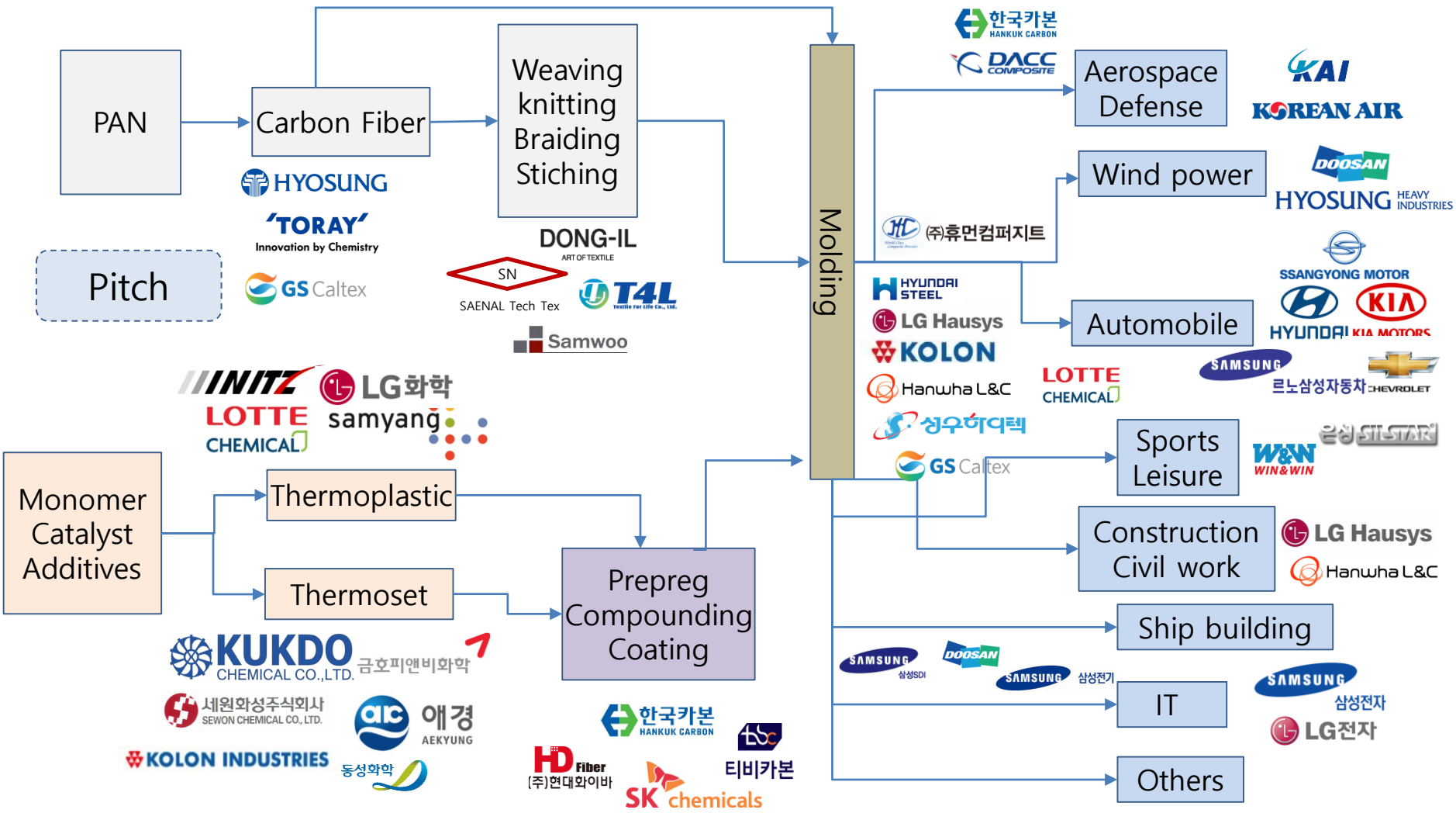




Ref. M. Kuhnel and T. Kraus, The global CFRP market 2016, Experience composites, Augsburg, Sep. 2016

CFRP Korea Supply Chain Model



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Epoxy Composite Project Model for Automotive Industry in Korea

Epoxy Resin System

KUKDO, Olin, HEXION, HUNTSMAN (Enriching lives through innovation)

KUKDO, Olin, HEXION, HUNTSMAN (Enriching lives through innovation)

HYUNDAI MOBIS, DONGHEE, Hanwha L&C, HYUNDAI STEEL

HYUNDAI, KIA, KIA MOTORS

Carbon Fiber / Prepreg

HYOSUNG, TORAY (Innovation by Chemistry), MITSUBISHI CHEMICAL CARBON FIBER AND COMPOSITES, sgl carbon, TEIJIN

MITSUBISHI CHEMICAL CARBON FIBER AND COMPOSITES, HD Fiber (주)현대화이바, SK chemicals, 한국카본 HANKUK CARBON, 티비카본, HEXCEL, TORAY (Innovation by Chemistry)

LG하우시스, 성우하이텍, KOLON, (株)一志테크, 아진산업(주)

SAMSUNG 르노삼성자동차, SSANGYONG MOTOR

Equipment Manufacturer

Krauss Maffei Group, cannon (DEDICATED INDUSTRIAL SOLUTIONS), Hennecke (Polyurethane Technology), DIEFFENBACHER, SCHULER (Member of the ANDRITZ GROUP), CDI, MIKROSAM (CONTROL • AUTOMATION • ROBOTICS), Engineering Technology Corporation (Toray Group), Martin Pultrusion Group, PICO ind. (Percision Filament Winding Medical System), Fraunhofer

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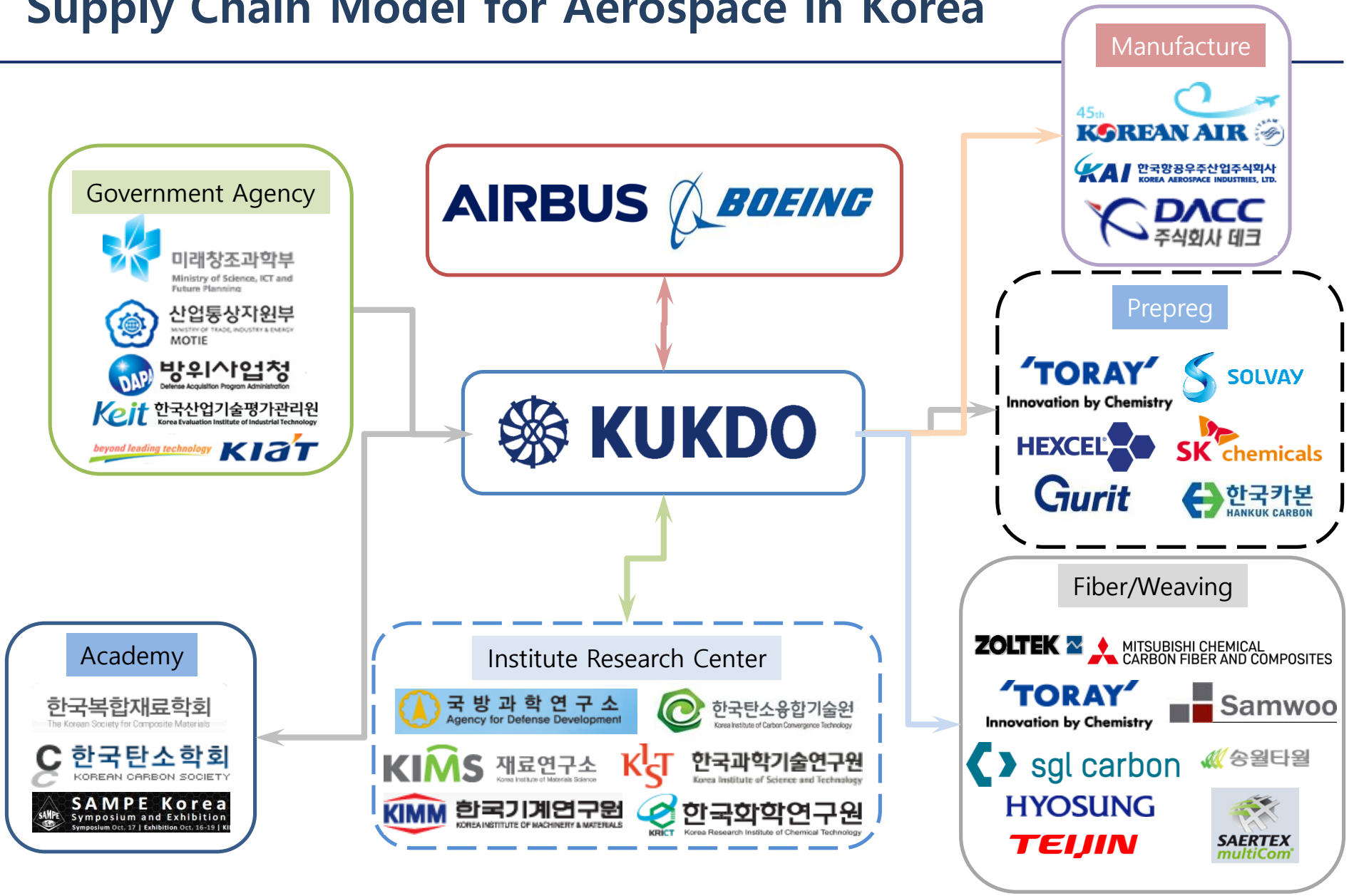
Supply Chain Model for Aerospace in Korea



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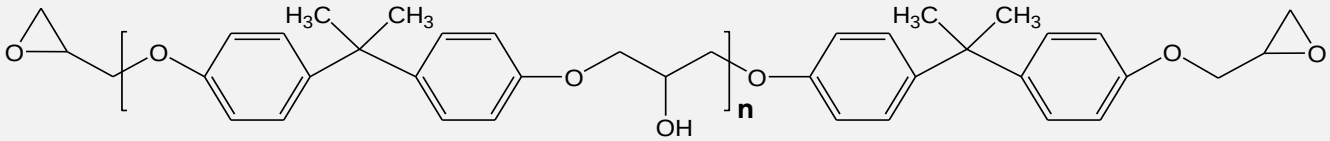
Base Epoxy Resins for Composite

Bisphenol A Type Epoxy Resin

Chemical Structure



	EEW (g/eq)	Viscosity (cps @25℃)
KDS-8128	170-175	4,000-5,000
KFR-502(EC)	179-184	9,000-11,000
KFR-503(EC)	184-190	12,000-13,200
KFR-5504	240-245	45,000-60,000 (@40℃)
KFR-5515	261-286	11,000-35,000 (Pa·s)
KFR-5516	276-306	39,000-110,000(Pa·s)
KFR-5517	290-327	160,000-350,000(Pa·s)
KFR-5518	330-350	20,000-40,000 (@75℃)
YD-011	455-495	500-1500 (@40℃)
YD-017	1,750-1,950	-

*** We have more products available in this category.**

E.E.W. ↓

Applications

High Purity Low Viscosity — **n=0** — **KDS-8128(P)** — Filament Winding, Infusion, RTM

KFR-502, KFR-502EC (BIO) — Standard Epoxy Resin
KFR-503, KFR-503EC (BIO) — Filament Winding, Infusion, RTM, Hand Lay-up, Prepreg

Liquid Medium Viscosity

Semi-Solid High Viscosity — **KFR-5504**, **KFR-5515**, **KFR-5516**, **KFR-5517**, **KFR-5518** — Prepreg

Solid — **YD-011 - 020** — Prepreg

n=20

E.E.W. ↑

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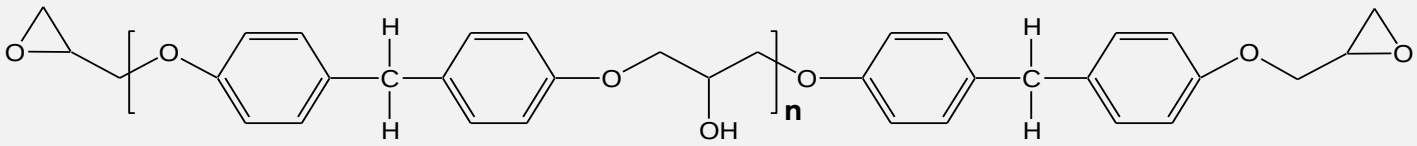
Base Epoxy Resins for Composite

Bisphenol F Type Epoxy Resin

Chemical Structure



Grades	EEW (g/eq)	Viscosity (cps @25℃)
KDS-8170	170-175	4,000-5,000
KDS-8161	160-170	2,000-3,000
KFR-513	165-175	2,000-5,000
YDF-170	160-180	2,000-5,000
YDF-161	170-180	5,000-7,000
YDF-2001	450-500	160-230 @150℃
YDF-2004	900-1000	50-60 ℃
KD-9007	1,750-1950	85-95 ℃*1

*1 softening point

*** We have more products available in this category.**

E.E.W. ↓

Applications

High Purity Low Viscosity — **n=0**

KDS-8170(P)
KDS-8161

Filament Winding, Infusion, RTM

Liquid Medium Viscosity

KFR-513, KFR-513EC BIO

Standard Epoxy Resin Filament Winding, Infusion, RTM, Hand Lay-up, Prepreg

YDF-170

YDF-161

YDF-2001

Solid — **n=20**

Prepreg

E.E.W. ↑

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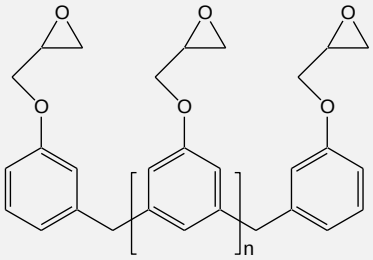
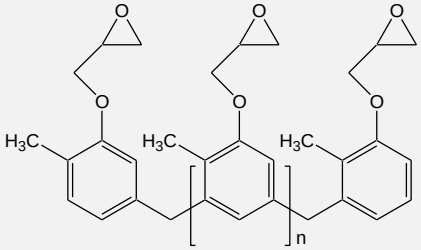
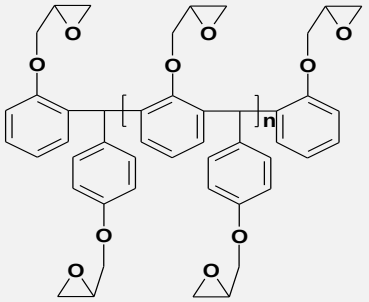
Special Epoxy Resins for Composite

Novolac Type Epoxy Resins

Chemical Structure







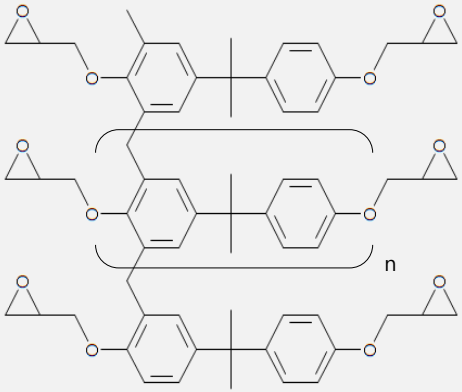
Product Name	EEW (g/eq)	Viscosity (cps at 52℃)	Product Name	EEW (g/eq)	Softening Point (℃)	Product Name	EEW (g/eq)	Viscosity (cps at25℃)
YDPN-631	165-185	A-D	YDCN-500-1P	190-210	50-54	KFR-36040	165-175	55,000-60,000
KDPN-1020	165-185	18,000-22,000	YDCN-500-4P	200-212	60-63	KDMN-1065	162-176	65-75℃
YDPN-638	170-190	40,000-50,000	YDCN-500-80P	200-212	66-70			
YDPN-641	170-190	800-1,100@150℃	YDCN-500-90P	200-220	85-90			
Semi Solid Epoxy Resin High Heat Resistance Good Chemical Resistance			Solid Epoxy Resin High Heat Resistance Good Chemical Resistance			High Heat Resistance Low Warpage Low Viscosity at High Temperature		
Prepreg(Hot Melt and Solvent Base), RTM			Prepreg(Hot Melt and Solvent Base), RTM			Prepreg(Hot Melt and Solvent Base),RTM		

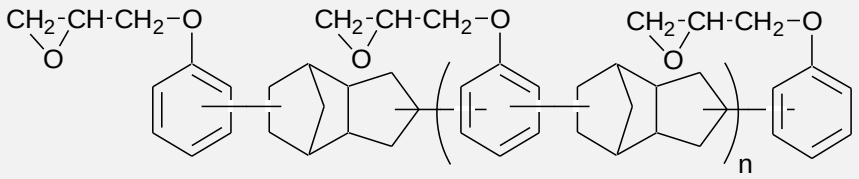
*** We have more products available in this category.**

Special Epoxy Resins for Composite

Novolac Type Epoxy Resins

Chemical Structure



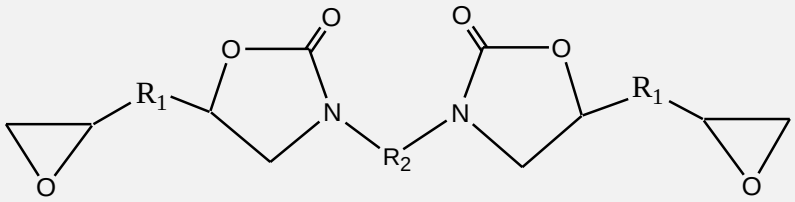


Product Name	EEW (g/eq)	Softening Point (℃)	Product Name	EEW (g/eq)	Softening Point (℃)
KBPN-110	190-230	60-70	KDCP-130	240-260	65-75
KBPN-115	200-230	70-80	KDCP-150	270-290	75-85
KBPN-120	200-230	80-90			
Semi Solid Epoxy Resin High Heat Resistance High Performance			Solid Epoxy Resin High Heat Resistance Low Moisture Absorption		
Prepreg(Hot Melt and Solvent Base), RTM			Prepreg(Hot Melt and Solvent Base), RTM		

*** We have more products available in this category.**

Isocyanate Modified Epoxy Resins

Chemical Structure



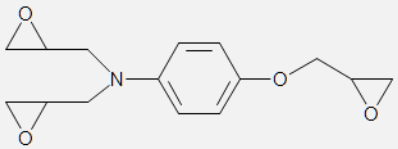
R_1 represents a residue of di-epoxide and R_2 represents an aromatic di-isocyanate

Product Name	EEW (g/eq)	Softening Point (℃)	Characteristics/Use
KD-2011	400-500	85-105	High Heat Resistant / Good Adhesion System / T_g 150℃
KD-2012H	400-500	95-110	High Heat Resistant / Good Adhesion System/ T_g 170℃
XD-2013H	500-600	100-120	High Heat Resistant / Good Adhesion System/ T_g 190℃
XD-9011	350-450	80-100	High Heat Resistant / Good Adhesion System/ BPF type
KFR-31085	300-400	80-85	High Heat Resistant / Adhesives for Aerospace / Tg 160℃

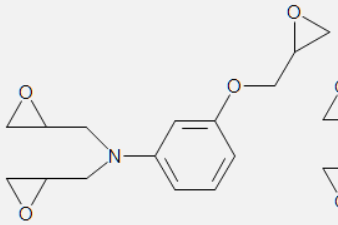
Special Epoxy Resins for Composite

Glycidyl Amine Type Epoxy Resins

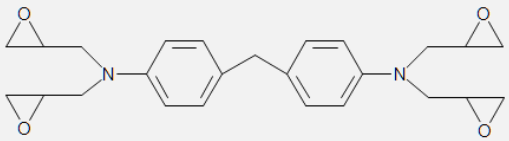
Chemical Structure



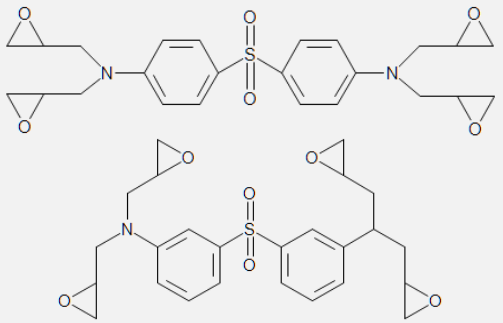
PA-805, KDS-8805



PA-808



PA-806
PA-806L



	PA-805 / KDS-8805 / PA-808	PA-806 / PA-806L / KDS-8806	Under Developing
Chemical Name	Triglycidy para-aminophenol (TGPAP) Triglycidyl meta-aminophenol (TGMAP)	Tetraglycidyl Diaminodiphenylmethane(TGDDM)	3, 3'- Tetraglycidyl diaminodiphenylsulfone 4, 4' – Tetraglycidyl diaminodiphenylsulfone
Features	Liquid Epoxy Resin High Heat Resistance Good Chemical Resistance	Liquid to Semi-solid Epoxy Resin High Heat Resistance Good Chemical Resistance	Semi-solid or Solid Epoxy Resin High Heat Resistance Low Viscosity at High Temperature
Applications	Prepreg Infusion, RTM, Filament Winding, Pultrusion	Prepreg – Hot Melt & Solvent Base RTM, Pultrusion, Filament Winding	Prepreg – Hot Melt,Solvent Base RTM

Specification

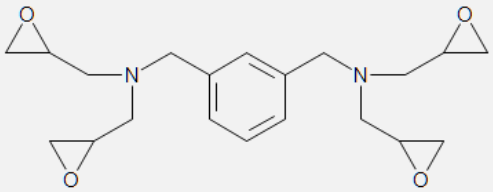
	EEW (g/eq)	Viscosity (cps at 25℃)	Hy-Cl (ppm)	Purity (%)
PA-805	105-115	2,000 – 5,000	< 2,000	60~65
KDS-8805	94-100	500-850	< 1,000	over 96
PA_806	115-130	8,000-18,000*1	< 2,000	80~85
PA-806L	111-117	3,000 – 6,000*1	800~1,800	86~92
PA-808	102-109	7,000 – 12,000	< 3,000	60~65
KDS-8808	94-102	1,500 – 4,000	< 2,000	Over 94

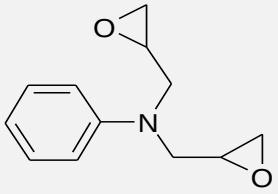
*1 Viscosity at 50℃

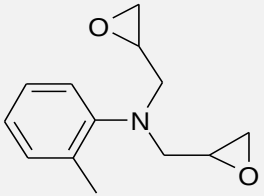
Special Epoxy Resins for Composite

Glycidyl Amine Type Epoxy Resins

Chemical Structure





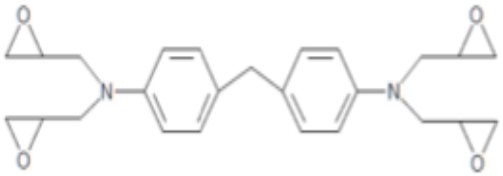


	PA-807	DA-802	DA-803
Chemical Name	Triglycidyl meta-xylenediamine (TGMXDA)	Diglycidylaniline	Diglycidyltoluidine
Features	Liquid Epoxy Resin High Heat Resistance Low Viscosity	Liquid Epoxy Resin High Heat Resistance Low Viscosity	Liquid Epoxy Resin High Heat Resistance Low Viscosity
Applications	Infusion, RTM, Filament Winding, Pultrusion	Infusion, RTM, Filament Winding, Pultrusion	Infusion, RTM, Filament Winding, Pultrusion

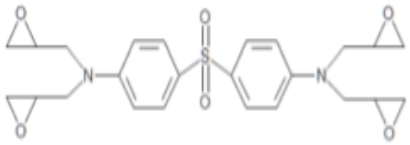
Specification

	EEW (g/eq)	Viscosity (cps at 25℃)	Color (Gardener)
PA-807	95-110	1,600-3,000	Max. 5
DA-802	106-116	90-160	Max. 6
DA-803	125-145	30-80	Max. 6

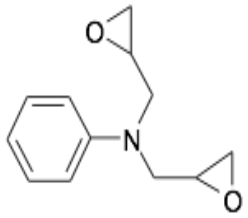
KUKDO Special Epoxy Resins for Aerospace



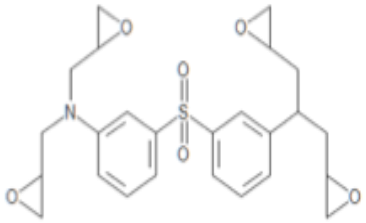
PA-806
PA-806L



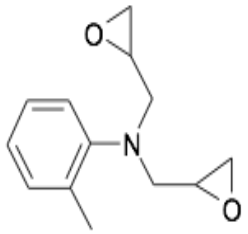
PA-809P



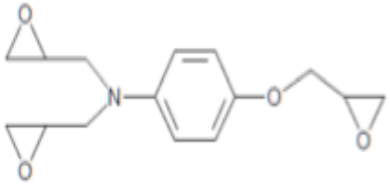
DA-802



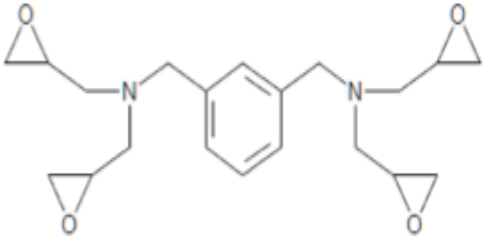
PA-809M



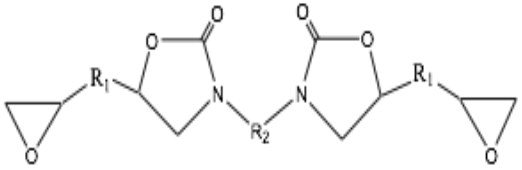
DA-803



KDS-8805, PA-805

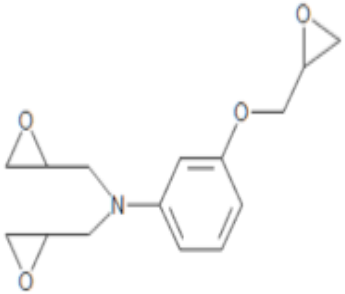


PA-807



R_1 represents a residue of diepoxide and
R_2 represents an aromatic diisocyanate

KFR-31085



PA-808

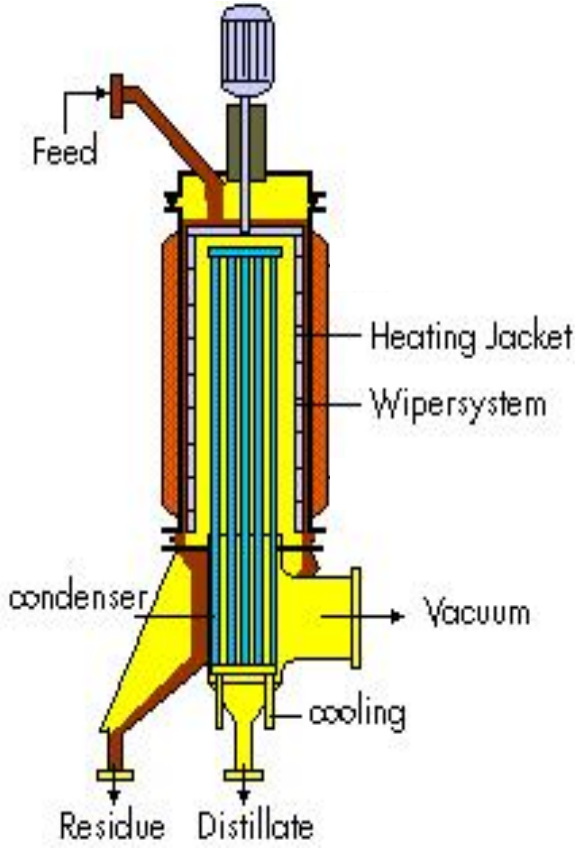
Global Best Chemical Materials Company beyond No.1 Epoxy Company. As the innovative and challenging chemical materials company, KUKDO always pursues the Best for customers.

KUKDO

Special Epoxy Resins for Composite
Low Viscosity and high purity epoxy resin

Principle of Process

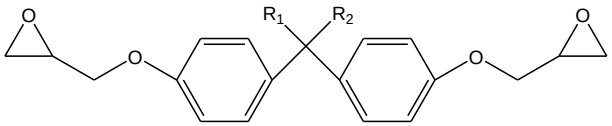
Vacuum-Distillation in Short path Evaporator with internal condenser



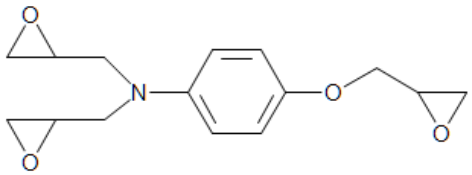
- Continuous purification process
  - ⇨ Short residence time
- High vacuum condition (1~0.001 mbar)
  - ⇨ Low evaporation temperature
- Evaporation from thin film by wiper system
  - ⇨ Molecular Distillation Technology
- Distillate discharged along internal condenser
  - ⇨ High Purity Epoxy Resin (n=0 : over 98%)

Special Epoxy Resins for Composite
Low Viscosity and high purity epoxy resin

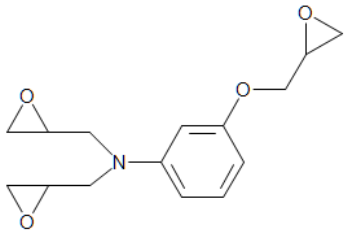
Chemical Structure



R_1, R_2=CH_3 or H



Triglycidy para-aminophenol (TGPAP)



Triglycidyl meta-aminophenol (TGMAP)

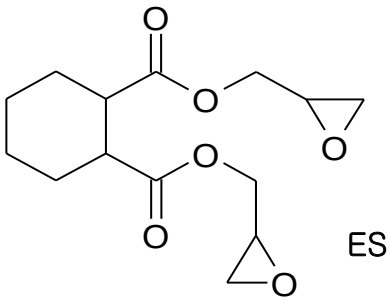
Specification

Product	EEW (g/eq)	Hy-Cl, ppm	Total-Cl, ppm	Viscosity (cps)	Purity (n=0)%	Notification
KDS-8170	155~160	< 100	< 700	1,000~2,000	Over 98	BPF Type
KDS-8170P	155~160	< 30	< 200	1,000~3,000	Over 97	BPF Type
YD-128	**184~190**	**< 500**	**1,500~2,000**	**11,500~13,500**	**80~84**	**BPA Type**
KDS-8128	170~175	< 150	< 700	3,000~5,000	Over 98	BPA Type
KDS-8128P	170~175	< 30	< 200	3,000~5,000	Over 97	BPA Type
KDS-8161	160~170	< 100	< 700	2,000~4,000	Over 98	*Non Crystalline*
PA-805	**105~115**	**< 2,000**	**<10,000**	**1,500~5,000**	**60~65**	**TGPAP Type**
KDS-8805	94-100	<1,000	<8,000	500~850	Over 96	TGPAP Distilled
PA-808	**102-109**	**<3,000**	**<10,000**	**7,000~12,000**	**60~65**	**TGMAP Type**
KDS-8808	94-102	<2,000	3,000~8,000	1,500~4,000	Over 94	TGMAP Distilled

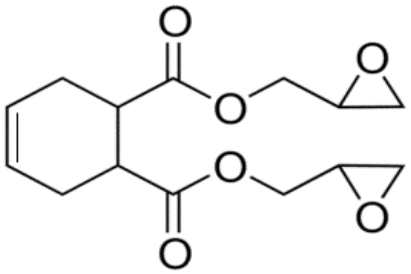
Special Epoxy Resins for Composite

Cycloaliphatic Epoxy Resins

Chemical structure



ES-602



ES-603

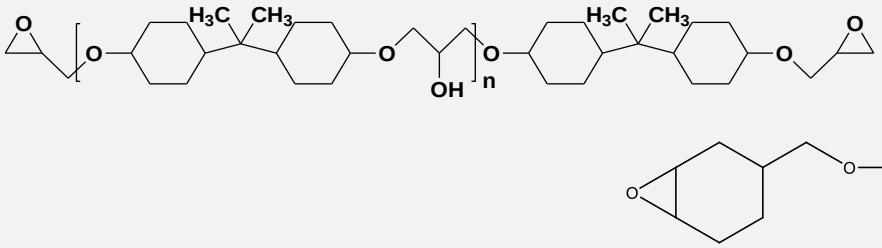
Chemical Name	Hexahydrophthalic acid diglycidyl ester	TetraHexyldrophthalic acid diglycidyl ester
Products Name	ES-602 (CY-184). ES-603(CY-182,183) equivalent	
Feature	Low viscosity,Provide particularly excellent Weather resistance to epoxy resin	
Applications	Infusion, RTM, Filament Winding, High Voltage Electric Molding, LED	

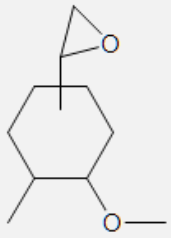
Specification

	EEW (g/eq)	Viscosity (cps at 25℃)	Hy-Cl(wt%)	T-Cl (wt%)	Color(APHA)
ES-602	164-177	600-900	1.5 Max	1.5 Max	50 Max
ES-603	150-175	600-1,200	2.0 Max.	2.0 Max.	100 Max

Special Epoxy Resins for Composite
Cycloaliphatic Epoxy Resins

Chemical Structure





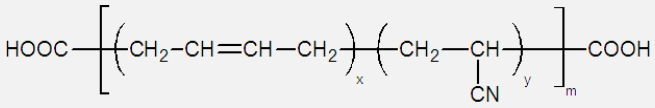
	ST-3000	KFR-221/KFR-226	KFR-225
Chemical Name	Diglycidyl ether of hydrogenated bisphenol A	3,4-epoxycyclohexylmethyl-3′,4′-epoxy cyclohexanecarboxylate	1-2-Epoxy-4(2-oxiranyl)-Cyclohexane of 2,2-bis (Hydoroxy methyl)1-butanol / (3'-4'-Epoxycyclohexane) Methyl 3'-4'-Epoxycyclohexyl-carboxylate
Features	Liquid Epoxy Resin High Heat Resistance Low Viscosity	Liquid Epoxy Resin High Heat Resistance, Low Viscosity	Liquid Epoxy Resin High Heat Resistance, Low Viscosity
Applications	Infusion, RTM, Filament Winding, Pultrusion	Infusion, RTM, Filament Winding, Pultrusion	Infusion, RTM, Filament Winding, Pultrusion

Specification

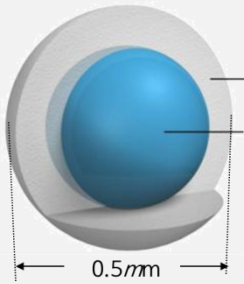
	EEW (g/eq)	Viscosity (cps at 25℃)	Color
ST-3000	220-240	2500-4000	Max 2 (G)
KFR-221	95-115	250-250	-10 (APHA)
KFR-226			
KFR-225			

Special Epoxy Resins for Composite
Flexible Epoxy Resins

Chemical Structure



CTBN
(Carboxyl Terminated Butadiene Nitrile Rubber)



Acryl Core Shell

Excellent Impact Resistance
Wide Service Temperature : -40-120℃
(can be controlled by customer's need)

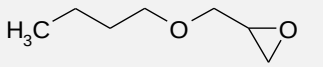
Specification

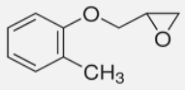
CTBN Modified			Acryl Coreshell			Urethane Modified		
Product	EEW	Viscosity	Product	EEW	Viscosity	Product	EEW	Viscosity
KFR-5521	1,500-1,800	1,600-5,500 @150℃	**KFR-5531**	240-260	6,000-10,000 @ 50℃	**UME-305**	230-270	5,000-12,000
KFR-5522	244-246	80,-000-100,000 @ 52℃	**KR-627**	190-210	10,000-30,000	**UME-330**	265-280	10,000-40,000 @ 45℃
KR-170	200-235	30,000-60,000	**KR-628**	220-240	40,000-60,000			
KR-207	175-205	2,000-3,000						
KR-450	400-500	Semisolid						
KR-818	370-730	Semisolid						

*** We are more products available in this category.**

Reactive Diluents

Chemical Structure


ME-100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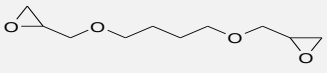
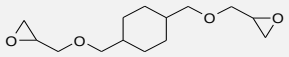

DE-200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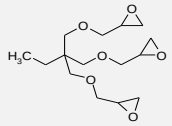
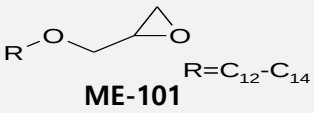

PE-300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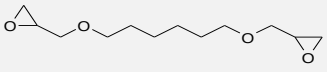
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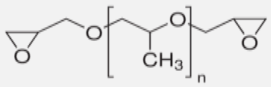
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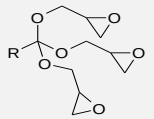
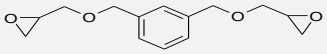

PE-412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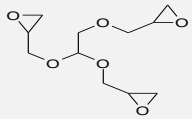
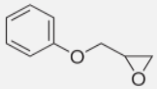
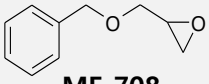

PE-311


ME-700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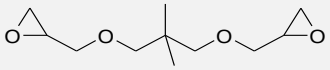
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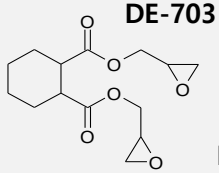
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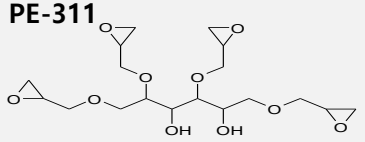
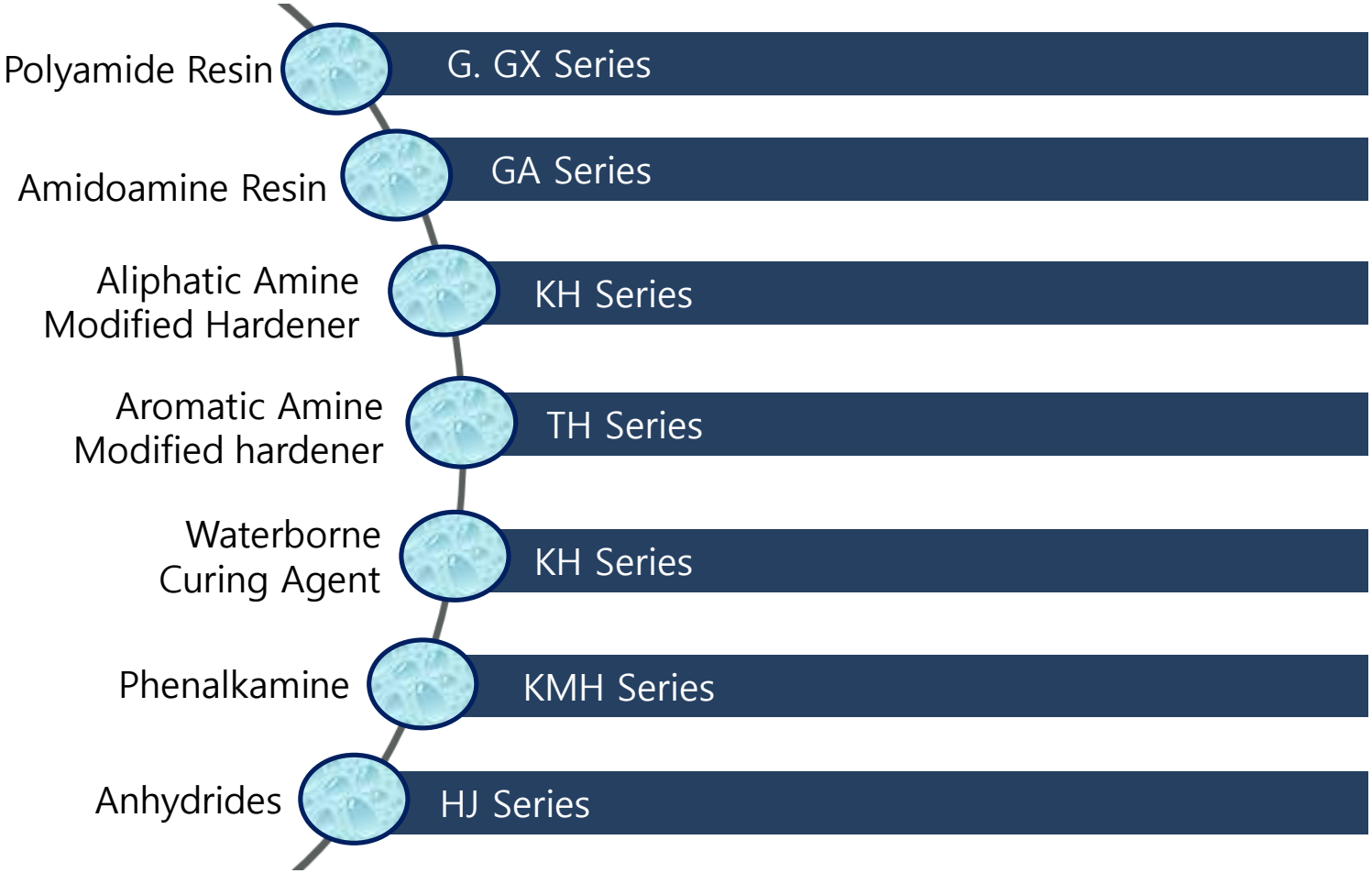

PE-510

Specification

Mono-functional Reactive Diluents			Di-fucntaionl Reactive Diluents			Multi-functional Reactive Diluents		
Product	EEW(g/eq)	Viscosity (cps@25℃)	Product	EEW(g/eq)	Viscosity (cps@25℃)	Product	EEW(g/eq)	Viscosity (cps@25℃)
ME-100	145-155	1-5	**DE-200**	120-140	10-18	**PE-300**	135-145	100-145
ME-101	275-300	5-10	**DE-202**	140-155	15-30	**PE-311**	135-150	200 Max
ME-700	150-165	4-8	**DE-203**	130-145	10-18	**PE-412**	550-650	300-500
ME-701	170-195	5-10	**DE-204**	150-165	60-75	**PE-510**	175-190	4,000-6,000
ME-708	200-220	5-10	**DE-207**	185-215	20-50			
			DE-703	120-135	300-500			
			DE-704	170-180	-			
			ES-602	164-177	600-900			

Outline of KUKDO Curatives



Epoxy System for Various Composite Application

Infusion Systems

Hand Lay-up(Laminate) Systems

Prepreg Systems

Filament Winding Systems

Pultrusion Systems

RTM Systems

KUKDO Epoxy System for Composite

Infusion Resin KFR120, 121, 123 series	**Hardener** KFH-141, 150, 151, 160, 163, 164 series
Mold Production Systems KFR-320, 330 series	**Hardener** KFH-350 series
Hand Layup(laminate) Systems KFR-520, 530 series	**Hardener** KFH-548, 549, 550, 560, 555 series
Prepreg Systems KFR-5504, 5515, 5516, 5517, 540 series	**Hardener** KFH-9106, 2555S, Modified DICY series
Filament Winding Systems KFR- 120, 520, 502, 503, 221, 805, 806 series	**Hardener** KFH-3349, 3353, 9A, 9B, 9590H, NMA, KH-100 series
Pultrusion Systems KFR- 120, 520, 502, 503, 5131, 6016 series	**Hardener** KFH-9580, 9581, 9A, 9B, 9820 series
RTM Systems KFR-36001, 36010, 36050, 36100 series	**Hardener** KFH-36301, 36302, 36303, 36304, 36350, 36100 series

Overview of System Epoxy for Composites

KUKDO

KUKDO Epoxy System for Composites I

cnc@kukdo.com

		Part B	KFH-141	KFH-150	KFH-151	KFH-163	KFH-163	KFH-1635	KFH-164	KFH-5478	KFH-350	KFH-3350	KFH-548	KFH-549	KFH-555	KFH-560	KFH-730FL	KFH-740FL	KFH-562	KFH-3348	KFH-3350	KH-100	KFH-3348	KFH-3350	KH-100	HJ-2200M	HJ-2200V	KFH-9584	KFH-9585	KFH-9820	KFH-9590H	KFH-9581	KFH-9580	KFH-9581	KFH-9830	DICY/2MI	KFH-9106	KFH-55301	KFH-36301	KFH-36302	KFH-36303	KFH-36304	KFH-36304	KFH-36307	KFH-36308	KFH-36309	KFH-36330	KFH-36306
		Part A	KFR-121	KFR-120	KFR-120	KFR-120	KFR-123	KFR-123	KFR-123	KFR-1278	KFR-320	KFR-120V	KFR-520	KFR-520	KFR-520	KFR-520	KFR-730FL	KFR-730FL	KFR-120V	KFR-502	KFR-502	KFR-502	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-8128T	KFR-520	KFR-5131	KFR-5131	KFR-6025	KFR-540A70	KFR-540	KFR-55001	KFR-36001	KFR-36001	KFR-36001	KFR-36001	KFR-36002	KFR-36002	KFR-36002	KFR-36009	KFR-36030	KFR-36040
Infusion	Fast		●	●	●																			○																								
	Standard					●	●			●														○																								
	Slow							●	●																	○	○	○	○	○	○	○	○	○													
	High Tg										●											●			●	○	○	○	○	○	○	○	○	○													
	High Flexibility																											○	○	○																	
	Mold Production										●																																				
Hand Lay-up	Fast												●	●																										○	○	○	○	○	○	○	○	○	○
	Standard														●																																	
	Long															●																																
	High Tg																																												○		○
Adhesives	Standard																●																														
	Slow																	●																													
Filament Winding	RT Cure System																		●																												
	Fast Cure System																			●																												
	Standard																				●		●	●		●	●				●															
	High Tg																					●			●																						
	High Elongation																											●	●	●																	

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Overview of KUKDO System Epoxy for Composites

KUKDO

KUKDO Epoxy System for Composites II

cnc@kukdo.com

		Part B	KFH-141	KFH-150	KFH-151	KFH-163	KFH-163	KFH-1635	KFH-164	KFH-5478	KFH-350	KFH-3350	KFH-548	KFH-549	KFH-555	KFH-560	KFH-730FL	KFH-740FL	KFH-562	KFH-3348	KFH-3350	KH-100	KFH-3348	KFH-3350	KH-100	HJ-2200M	HJ-2200V	KFH-9584	KFH-9585	KFH-9820	KFH-9590H	KFH-9581	KFH-9580	KFH-9581	KFH-9830	KFH-9830	DICY	KFH-9106	KFH-55301	1 Componnet	KFH-36301	KFH-36302	KFH-36303	KFH-36304	KFH-36304	KFH-36307	KFH-36308	KFH-36309	KFH-36330	KFH-36306
		Part A	KFR-121	KFR-120	KFR-120	KFR-120	KFR-123	KFR-123	KFR-123	KFR-1278	KFR-320	KFR-120V	KFR-520	KFR-520	KFR-520	KFR-520	KFR-730FL	KFR-730FL	KFR-120V	KFR-502	KFR-502	KFR-502	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-503	KFR-8128T	KFR-520	KFR-5131	KFR-5131	KFR-6025	KFR-6026	KFR-540A70	KFR-540	KFR-55001	KFR-55010	KFR-36001	KFR-36001	KFR-36001	KFR-36001	KFR-36002	KFR-36002	KFR-36002	KFR-36009	KFR-36030	KFR-36040
Pultrusion	Low Viscosity																														●																			
	Standard																															●	●																	
	High Tg > 180℃																																	●															
	High Tg > 220℃																																		●														
	i-RTM																																								●	●	●	●	●	●	●	●	●	●
Prepreg	Solvent System – Standard																																			●														
	Hot Melt System – Standard																																				●	●	●											
	Fast Curing System for PCM																																						●											
	Standard System for Tow Prepreg																																							●										
HP-RTM	Ultra Fast Curing System																																								●	●		●	●					
	Fast Curing																																									●								
	High Elongation																																														●			
	High Tg																																															●		●
	Long Pot Life for Large Part																																														●	●		
	Fire Retardant/UL94V-0																																															●	
Resin Transfer Molding	Standard		●	●	●	●	●	●	●	●	●	●								○	○		○	○		●	●	●	●	●	●	●	●	●																
	High Tg																					●			●										●	●														●

Global Best Chemical Materials Company beyond No.1 Epoxy Company. As the innovative and challenging chemical materials company, KUKDO always pursues the Best for customers.

Processes and Its Key Requirements

Infusion
Low Viscosity
Low Exotherm
Long Pot Life

Hand Lay-up
Low Exotherm
Rheology Control
(Fast Curing)

Filament Winding
Rheology Control
(Appropriate viscosity)
Fast Curing

Pultrusion
Appropriate viscosity
Fast Curing
Long Pot Life
Easy Mold Release

Prepreg
Tacky Property
Long Shelf live
Easy Mold Release

RTM/WCM
Low Viscosity
Short Cycle Time
(Fast Curing)
Short Gel Time
Easy Mold Release

Considerable Factors of Process & Property for **Epoxy Matrix Composite**

Mixed Viscosity
Rheology(Viscosity Development)
Cure Cycle Time
Tacky free time
Exothermic temperature
Gel Time
Pot Life
Adhesion properties
Tg (Dry & Wet)
Tensile Strength (Stiffness)
Toughness (KIC, GIC)
Elongation
Releasing(Surface)
Cryogenic Properties
Weatherability
Water Absorption

Optimized Performance Product

Applications and Its Key Requirements

Automotive
High Tg (Up to 160℃, DMA G' Onset)
Excellent Tensile strength(Stiffness)
High Toughness(K_{IC}/G_{IC})
Fast Curing (Fast Cycle Time)
Reasonable Price Level

Aerospace
Very High Tg (Up to 220℃, DMA G' Onset)
and high wet Tg (up to 160℃)
Excellent Tensile strength(Stiffness)
High Toughness(K_{IC}/G_{IC})
Cryogenic Properties

Industrial
Excellent Tensile Strength(Stiffness)
High Toughness(K_{IC}/G_{IC})
Reasonable Price Level

Wind Energy
Low Viscosity
Long Pot Life & Exotherm
High Stiffness and Elongation
Weatherability
Low Water Uptake

Basic condition of Epoxy System depend on the process

Process	Mix Viscosity	Curing Cycle	Exothermic Peak Temperature	Gel Time	Thixotropic
Infusion	Max 300cps	1hr~24hr	The lower The better	The longer The better	X
Hand Lay-up	Max 2,000cps	10~24hr	The lower The better	Case by case	O
F/W	300~2000cps	1~24hr	The lower The better	Case by case	▲
Pultrusion	200~4000cps	Max 5 min	-	Fast	X
Prepreg	Semi-Solid/ Solution	5min~ 12hr	The lower The better	Case by case	X
RTM	Max 1000cps	1~24hr	The lower The better	Case by Case	X
HP-RTM/WCM	Max 100cps	Fast Max 10 Min	-	The longer The better	X

Epoxy System for Automotive Parts (Body In White)

Engine Protect Bar

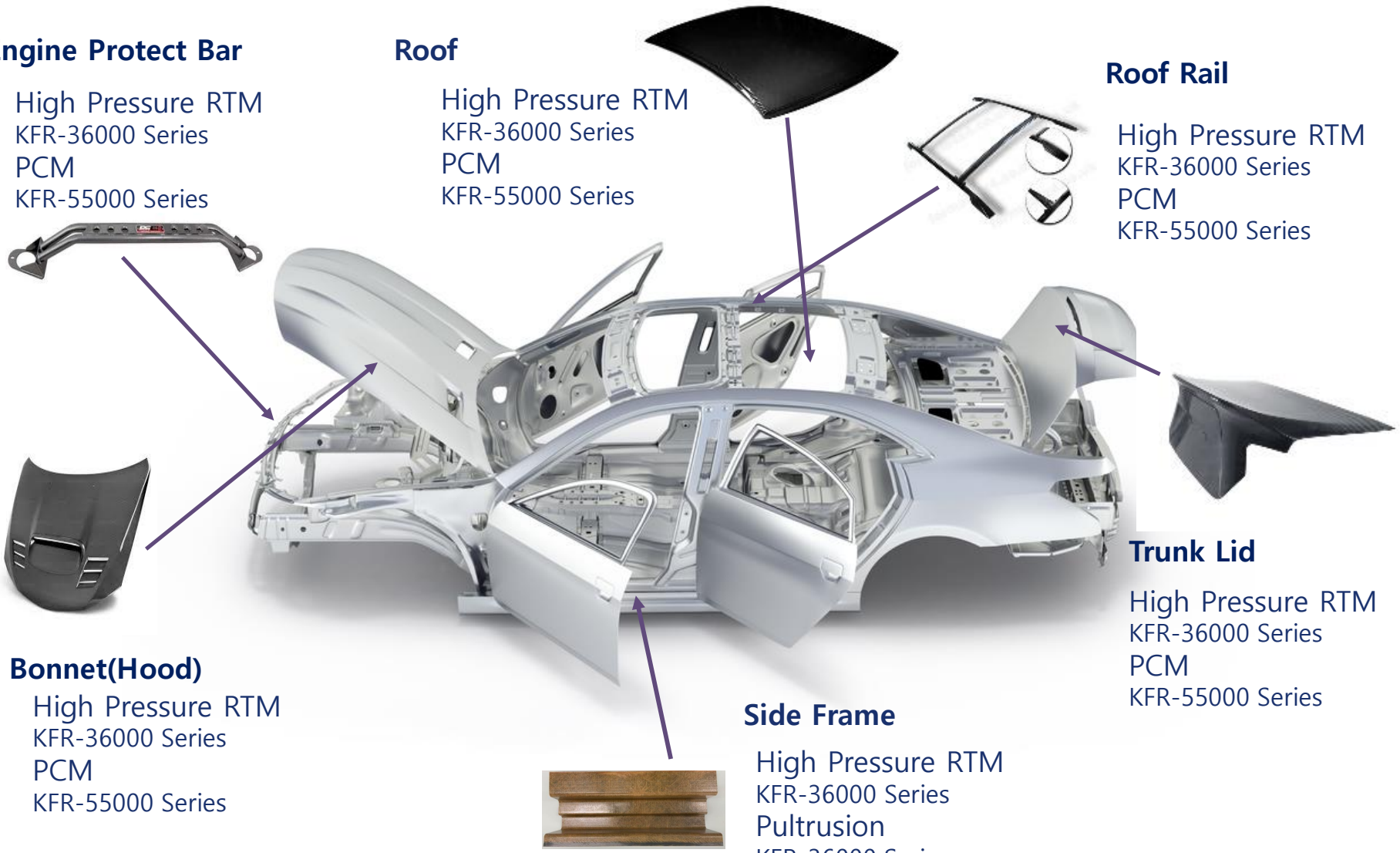
High Pressure RTM
KFR-36000 Series
PCM
KFR-55000 Series

Roof

High Pressure RTM
KFR-36000 Series
PCM
KFR-55000 Series

Roof Rail

High Pressure RTM
KFR-36000 Series
PCM
KFR-55000 Series



Trunk Lid

High Pressure RTM
KFR-36000 Series
PCM
KFR-55000 Series

Bonnet(Hood)

High Pressure RTM
KFR-36000 Series
PCM
KFR-55000 Series

Side Frame

High Pressure RTM
KFR-36000 Series
Pultrusion
KFR-36000 Series

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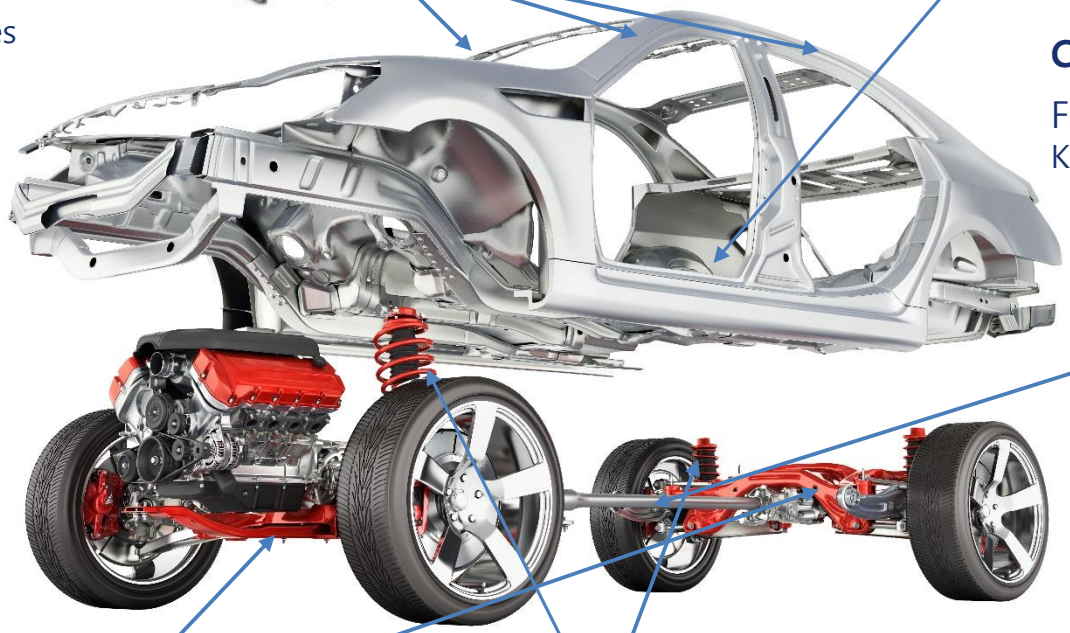
KUKDO

Epoxy System for Automotive Parts (Body In White)

Pillars (A, B & C)

High Pressure RTM
KFR-36000 Series
PCM
KFR-55000 Series



CNG, Hydrogen Gas Tank

Filament Winding (Wet & Tow)
KFR-500 Sereis

Leaf spring

Prepreg
KFR-55000 series
High pressure RTM
KFR-36000 series

Suspension

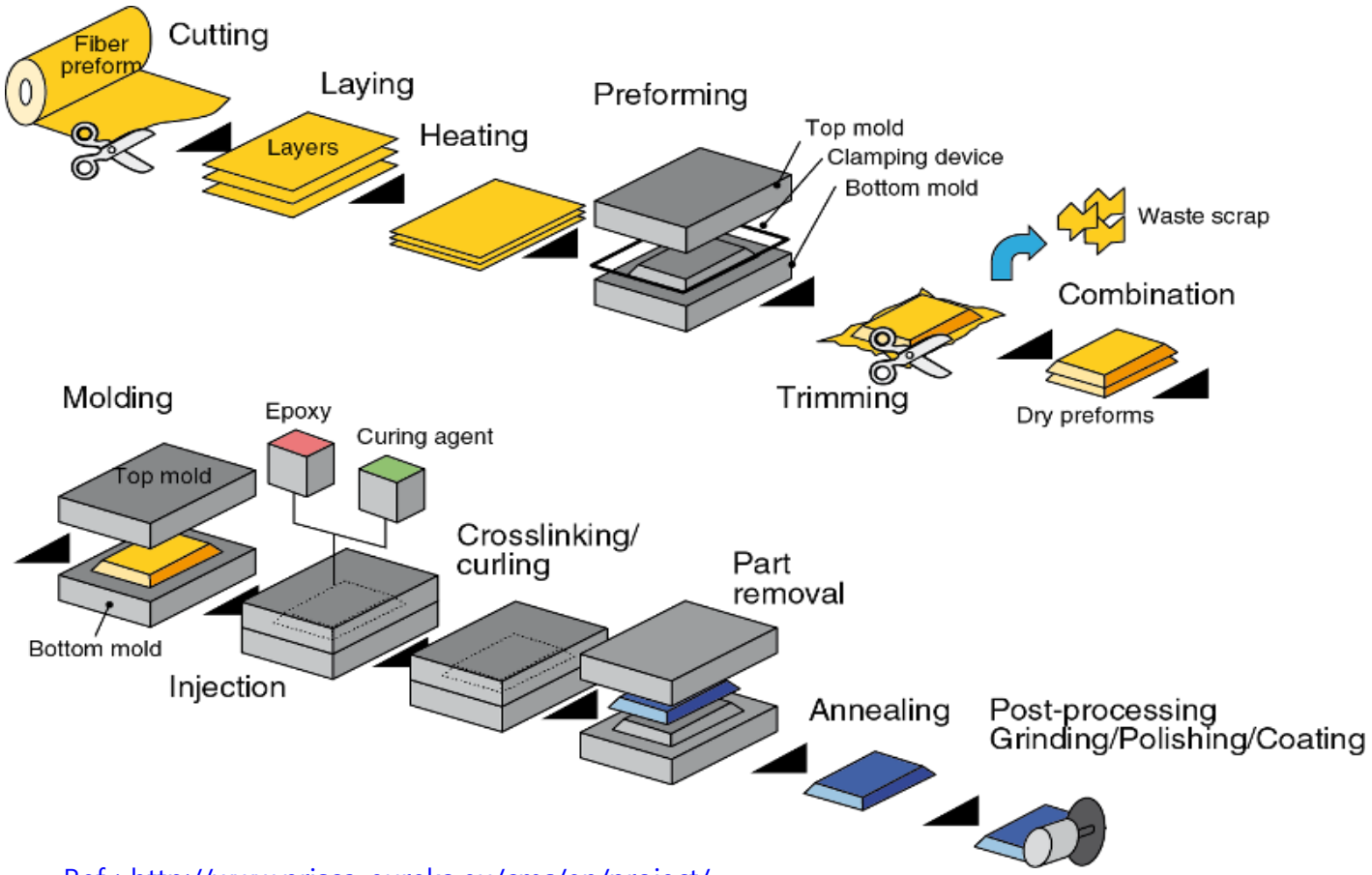
RTM
KFR-500 Series
Pultrusion
KFR-6015 Series
KFR-36000 Series

Battery Housing

HP-RTM
KFR-36030 Series

Epoxy System for RTM

Concept – Understanding HP-RTM Process



Ref : http://www.prisca-eureka.eu/cms/en/project/

HP-RTM / WCM Process

Product Line Up

Resins	Hardener	GEL TIME (sec @120℃) (HOT PLATE)	Mixing Viscosity (cps @25℃)	Cured Tg(℃) (DMA / Loss Tg)	Cycle Time(sec)	Properties/Application
KFR-36001	KFH-36301	25~30	2500~3500	120~130	60	Ultra Fast curing
KFR-36001	KFH-36302	40~50	2000~2500	120~130	70	Ultra Fast curing
KFR-36001	KFH-36303	50~65	1000~1500	120~130	90	Fast curing
KFR-36001	KFH-36304	25~30	2000~3000	120~130	60	Ultra Fast curing
KFR-36002	KFH-36304	25~30	2500~3000	120~130	60	Ultra Fast curing
KFR-36002	KFH-36307	65~80	1000~2000	105 ~ 115	150	High Elongation
KFR-36040	KFH-36306	40~50	4500~6000	180 ~ 190	120	High Tg
KFR-36002	KFH-36308	120~150	1000~1500	120~130	240	Long pot life
KFR-36009	KFH-36309	130~150	1500~4000	155 ~ 165	240	Wet Compression Molding
KFR-36030	KFH-36330	30~60	4500~6000	90 ~ 100	120	Fire Retardant/ UL94 V0 (Under Development)

HP-RTM / WCM Process

Test History

Products	Characteristics	Test History
KFR-36001/KFH-36301	General Type/Fast Curing	Jul, 2015/Krauss-Maffei (Germany) Trial Test
KFR-36001/KFH-36304	General Type/Fast Curing	Jul, 2015/Krauss-Maffei (Germany) Trial Test
KFR-36002/KFH-36301	General Type/Fast Curing	Jul, 2015/Krauss-Maffei (Germany) Trial Test May, 2016/Cannon (Italy) Trial Test
KFR-36002/KFH-36307	High Elongation/Low Viscosity	Sep, 2016/KCTECH (KM Machine) Trial Center tunnel (Domestic Car)
KFR-36002/KFH-36308	Long Pot Life/Low viscosity	May, 2017/(Cannon Machine, Italy) Trial Roof (Hyundae Steel) Local Production(Current)
KFR-36009/KFH-36309	Middle Tg/Long Pot Life	Starting from Jun, 2017 (Cannon machine) Hanwha(Korea) Roof rail Trail Production
KFR-36040/KFH-36306	High Tg/Fast Curing	Sep, 2016/KCTECH(Korea) Trial Test (KM machine)
KFR-36030/KFH-36330	Flame Retardant Type	Sep. 2017/KIST (Korea) Trial Test (KIST,KM) LG Hausys Battery Carrier

HP-RTM / WCM Process

Long Pot-Life Type

Application

- Automotive – Epoxy system for Roof (Large Scale part)

Product

- KFR-36002 + KFH-36308

Application (HP-RTM/Cannon)

Epoxy System for HP-RTM

Fast Curing/High Elongation Anhydride Type – Elongation > 10%

Application

- Automotive – WCM and Pultrusion Test in (Kukdo, KCTECH, Shinsung Materials, GHI)

Product

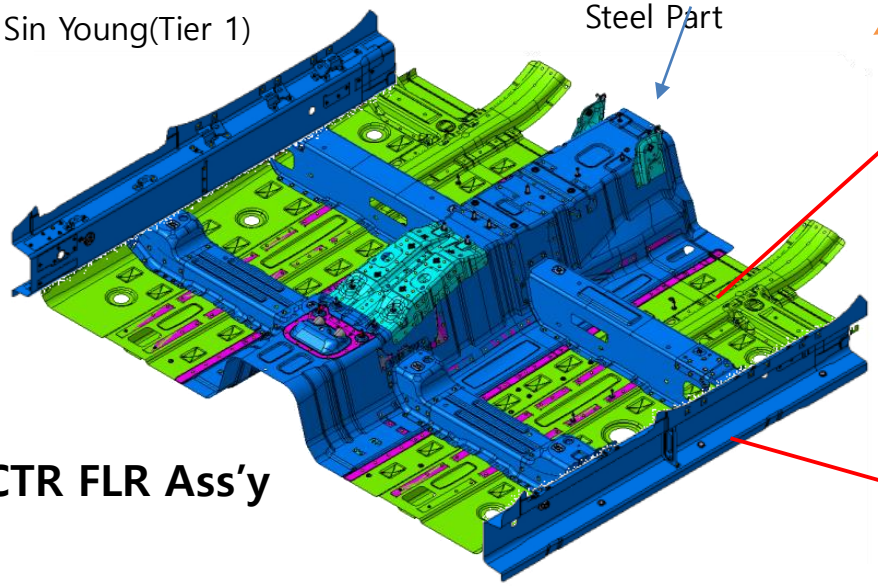
- KFR-36000 Series with KFH-36300 Series

SVHC Free System

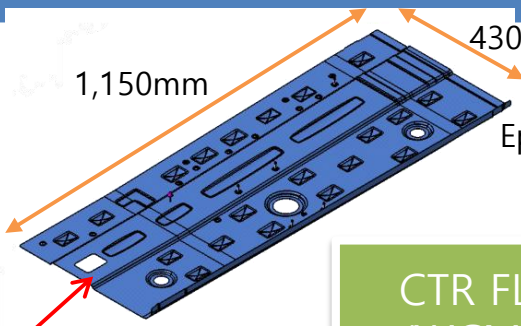
R&D Project : Korea Evaluation Institute of Industrial Technology(KEIT) grant funded by the Korea government(MOTIE)

Sin Young(Tier 1)

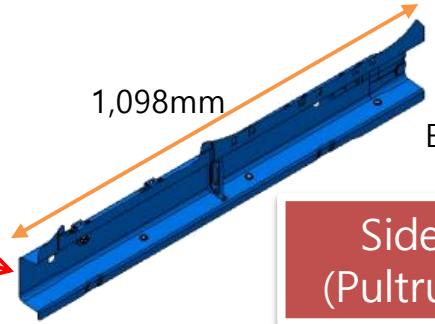
Center Tunnel Steel Part



CTR FLR Ass'y



CTR FLR Side (WCM, 0.65t)



Side Sill INR (Pultrusion, 1.2t)

HP-RTM / WCM Process

High Tg Type

Why High Tg?

- Finishing Process : Preparation → Electrodeposition → Base Coat → Top Coat

For the E-coat process, assembly should be used high temperature materials.

- Adjacent parts of Engine and Muffler (High Tg Parts)


Engine cover


Fender apron


Hood


muffler


Cowl


Radiator PNL

HP-RTM / WCM Process

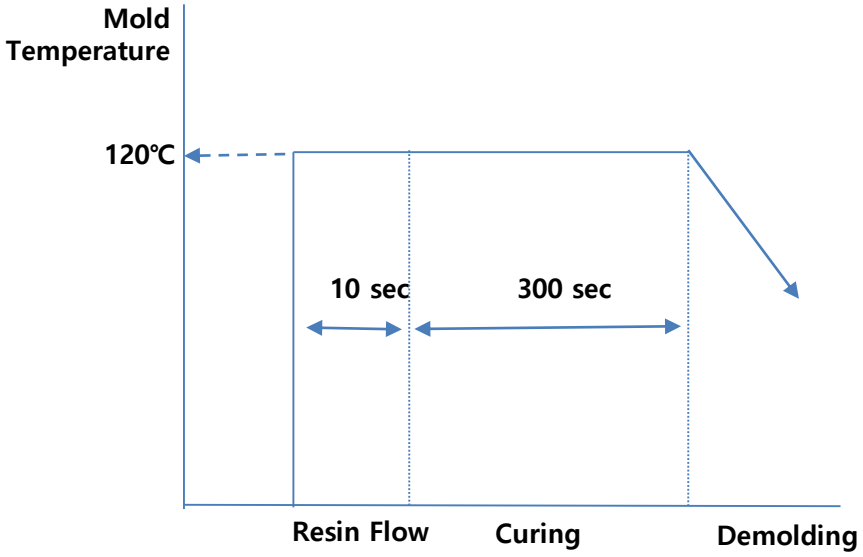
High Tg Type

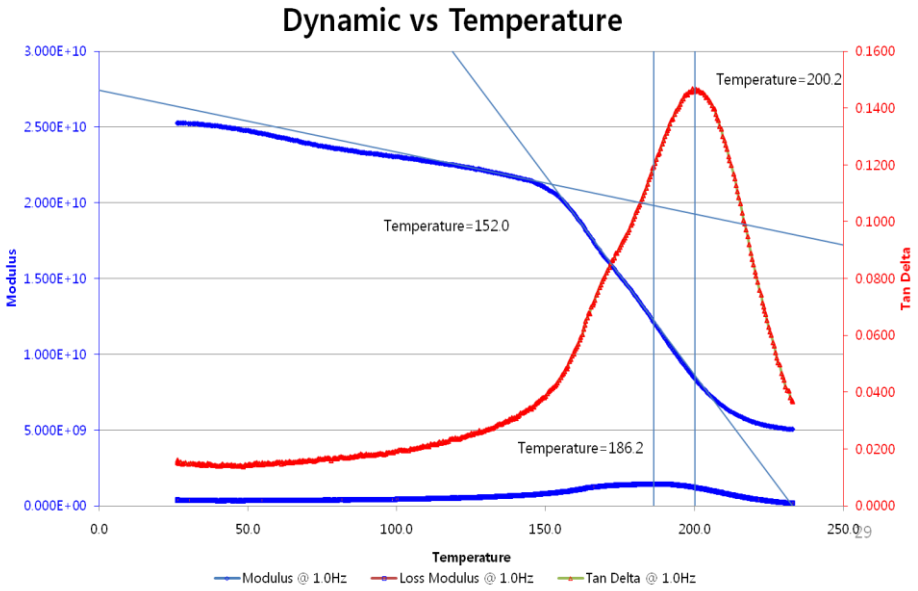
Application

- Automotive – Trial Tested in **KC-TECH (Korea), Very high Tg (186℃, Peak Temp of Loss Modulus)**

Product

- KFR-36040 + KFH-36306





HP-RTM / WCM Process

Flame Retardant System

Why Flame Retardant?

The increasing use of electronics in cars and other transport means results in more plastics being required for cables, electric and electronic parts, etc.

However, most polymer materials are inherently flammable and can be easily set on fire with a small ignition source, like a lighter, match, electric failure or mechanical overheating.

In a road accident, it may easily take 10 to 20 min before emergency services arrive, and if a car body is distorted, it may take up to 40 to 60 min to free the passengers. If a fire starts during this time, there is hardly any hope for the trapped people

Source :http://www.pinfa.org/images/core/brochures/PINFA_Transportation_Brochure_2010_Final_Version.pdf

HP-RTM / WCM Process

Flame Retardant System

Organic

- Graphite
- Graphene
- Graphene nanoplatelet

Nano-materials can increase viscosity and thixotropy : Not good for composite processing

Inorganic

- Titania
- Silica
- Zinc Oxide

Disturb the resin flow due to particles

Types

- Halogen
- Silica
- Nitrogen
- Phosphorus

Hybrid (Ex. N-P)

- Flame Retardant Test - FMVSS 302, UL94 V_0

HP-RTM / WCM Process

Flame Retardant System

Application

- Automotive – Epoxy system for battery pack module carrier

Product

- KFR-36030 + KFH-36330

Possible Application

Source : Carbon composite battery pack module carrier developed by LG Hausys

HP-RTM / WCM Process

Flame Retardant System

Certificate : V_0 Test

SGS

Test Report No. F690101/LF-CTSAYAA17-42551 Issued Date: 2017. 08. 03 Page 2 of 3

Sample No. : AYAA17-42551.001
Sample Description : No. 2 sample
Item / Part No. : N/A
Material : N/A

FLAMMABILITY (Ref. UL 94: 2013, 20mm VERTICAL BURNING TEST)

RESULTS						ACCEPTANCE CRITERIA		
AFTER FLAME TIME(T_1, T_2) (s)						V-0	V-1	V-2
	(1)	(2)	(3)	(4)	(5)			
T1	0.4	0.5	0.6	0.5	0.4	≤ 10s	≤ 30s	≤ 30s
T2	0.8	3.7	0.8	0.7	1.2			
AFTER FLAME(T_1) (s) + AFTER FLAME(T_2) (s)						≤ 50s	≤ 250s	≤ 250s
$T_1 + T_2$	9.6							
AFTER GLOW TIME(T_3) (s)						-	-	-
T3	0.0	0.0	0.0	0.0	0.0			
AFTER FLAME(T_2) (s) + AFTER GLOW(T_3) (s)						≤ 30s	≤ 60s	≤ 60s
$T_2 + T_3$	0.8	3.7	0.8	0.7	1.2			
BURN UP TO THE 125mm MARK						NO	NO	NO
125mm	NO	NO	NO	NO	NO			
IGNITION OF COTTON						NO	NO	YES
COTTON	NO	NO	NO	NO	NO			
CLASSIFICATION								
V-0								

T_1: Afterflame time after first flame application
T_2: Afterflame time after second flame application
T_3: Afterglow time after second flame application

Note 1) The test was conducted by applicant's request.
Note 2) Thickness: 3.23 mm
Note 3) Conditioning: (23 ± 2) °C, (50 ± 5) % R.H, 48 hours

SGS

Test Report No. F690101/LF-CTSAYAA17-42551 Issued Date: 2017. 08. 03 Page 3 of 3

Picture of Sample as Received :

AYAA17-42551.001

*** End of Report ***

F401 Version 4

Epoxy System for Filament Winding

Application – Automotive

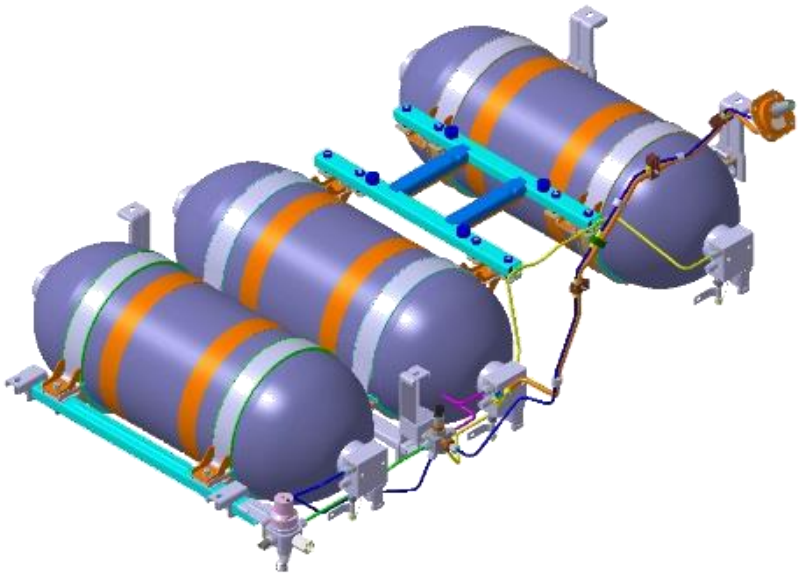
Application

- **Hydrogen Gas Tank for Fuel cell Electric Car**

Product

- Recommended System : KFR-503 with KFH-9584 Series

Hydrogen Fuel Gas Tank for NEXXO (HKM)
Type IV, 700bar



Epoxy System for Filament Winding

KUKDO System Epoxy for F/W

Amine System

Resin	Hardener	Mixing Ratio [wt%]	Mixing Viscosity ISO 2555 [cps at 25℃]	Pot life [min or hr]	Tg [℃]	Note.
KFR-120V	KFH-562	100 : 37	500 ~ 600	40~50min (100g scale)	60℃	RT cure system & (Membrane Filter)
	KFH-163	100 : 30	200 ~ 300	90~120min (1000g scale)	75℃	Standard amine (GRE, vessel)
KFR-502	KFH-3348	100 : 13	1000 ~ 2000	20~30min (100g scale)	110℃	Fast cure system
	KFH-3350	100 : 23	1000 ~ 2000	60~70min (1000g scale)	150℃	High Tg system
	KH-100	100 : 25	800 ~ 1000	>24hr	>140℃	High Tg system (Ballast pipe)
KFR-503	KFH-3348	100 : 13	1000 ~ 2000	20~30min (100g scale)	110℃	Fast cure system
	KFH-3350	100 : 23	1000 ~ 2000	60~70min (1000g scale)	150℃	High Tg system
	KH-100	100 : 25	800 ~ 1000	>24hr	>140℃	High Tg system (Ballast pipe)

Epoxy System for Filament Winding

KUKDO System Epoxy for F/W

Anhydride System

Resin	Hardener	Mixing Ratio [wt%]	Mixing Viscosity ISO 2555 [cps at 25℃]	Pot life [min or hr]	Tg [℃]	Note.
KFR-503	HJ-2200M	100 : 90	<1000	-	-	ME-THPA
	HJ-2200V	100 : 90	<1000	>16hr	125℃	Standard system
	KFH-9584	100 : 100	800 – 1200	>10hr	110℃	High elongation (>10%) (LPG vessel)
	KFH-9585	100 : 88	800 – 1200	>10hr	115℃	Fast cure system (120℃ 30min)
	KFH-9820	100 : 100	800 – 1200	>10hr	150℃	High Tg system
KFR-8128T	KFH-9590H	100 : 100	100 ~ 400	>10hr	155℃	Heavy Electronic (Dry Reactor)

Epoxy System for Pultrusion

Application – Automotive

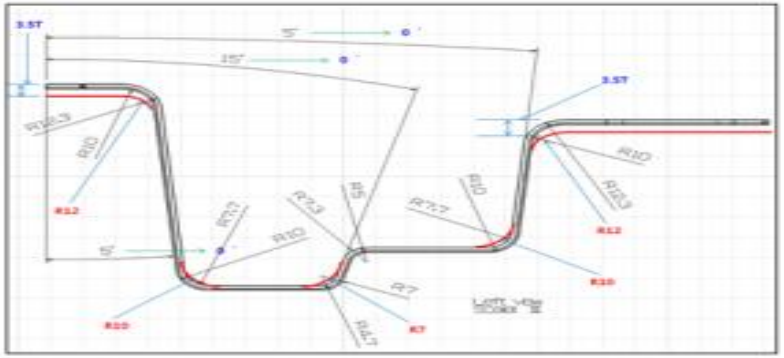
Application

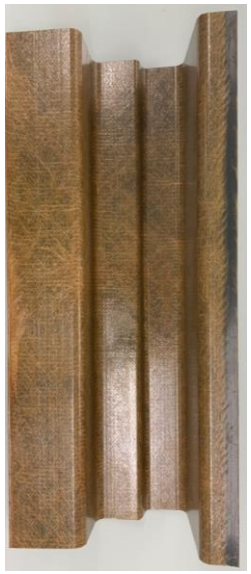
- Side Sill (High Tg, >180℃)

Product

- KFR-6025 with KFH-9830 Series

Composite Side Sill
-Pultruded Part
(SinSung/KUKDO as project prial)





Carbon/Glass Hybrid structure

Epoxy System for Pultrusion

KUKDO Epoxy System for Pultrusion

Chemical Properties of Neat Resine

Systems	Mixing Ratio [wt%]	Mixing Viscosity ISO 2555 [cps at 25℃]	Gel Time [sec]	Type	Tg [℃]
KFR-520/KFH-9581	100 : 95	1000 ~ 2000	40 sec at 160℃	Modified Bis A	100℃
KFR-503/KFH-9581	100 : 90	2000 ~ 3000	35 sec at 160℃	Modified Bis A	115℃
KFR-5131/KFH-9580	100 : 100	500 ~ 1000	35 sec at 160℃	Modified Bis F	130℃
KFR-5131/KFH-9581	100 : 100	500 ~ 1,000	35 sec at 160℃	Modified Bis F	120℃
KFR-5131/KFH-9584	100 : 115	500 ~ 1,000	-	Modified Bis F	110℃
KFR-6025/KFH-9830	100 : 145	2000 ~ 3000	55 sec at 160℃ 27 sec at 180℃	Modified Multifunctional	High Tg (>180℃)
KFR-6026/KFH-9830	100 : 185	1000 ~ 2000	23 sec at 160℃	Modified Multifunctional	High Tg (>220℃)

Epoxy System for Prepreg

Application – Automotive Industry

Application

- Carbon Composite B-pillar

Product

- KFR-55000 Series (5 Minutes Curing System)

Pillars of BMW 7 Series

Ref : https://www.compositesworld.com/articles/is-the-bmw-7-series-the-future-of-autocomposites

The Subject for Epoxy Composites in Automotive Industry

Low cost Mass Production

- Fast Cure Cycle time
- Fast and Easy Assembling Technology
- Robot Automation
- Fast and Easy Coating system

Repairing Technology for Epoxy composite

- Non Plating applicable for composite part
- Replacing cause cost and environmental issue
- Requiring Fast & Easy repairing technology
- Hand lay-up, partially Reinforcing and Wrapping ?
- Easy painting Technology after Repairing

Recycling Technology for Epoxy composite

- Pyrolysis Recycling Technology
  -> Mostly commercialized but High Energy required and still high cost
  -> Not possible for matrix recycling
- Chemical Recycling Technology
  -> Recyclable for CF and Matrix resins
  -> Comparably easy and low cost still under development

Global Best Chemical Materials Company beyond No.1 Epoxy Company. As the innovative and challenging chemical materials company, KUKDO always pursues the Best for customers.

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